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REDUCED-PRESSURE SILICON CRYSTAL GROWTH METHOD

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[There are no amendments to this patent.]

Claim

A reduced-pressure silicon crystal growth method characterized by the fact that silicon crystals are grown on

substrates using the resistance heating method; in this case, with the principal surface of each substrate being set vertically and parallel to the gas flow; with the periphery of the substrates being surrounded by a pipe made of silicon or fused silica glass with a nearly square cross section; and with the growth being performed in the reaction tube at a pressure of 25,000 Pa or lower.

Detailed explanation of the invention

Industrial application field

This invention pertains to a technology for growing a silicon film on a large number of substrates under reduced pressure.

Prior art

Several schemes have been proposed to grow a large number of silicon films at a pressure lower than atmospheric pressure (see: Japanese Kokoku Patent No. Sho 50[1975]-9471 and U.S. Patent No. 3,900,597). However, they have disadvantages. For the former, the number of substrates that can be processed is limited. For the latter, the growth rate is very low.

Purpose of the invention

The purpose of this invention is to solve the aforementioned problems of the conventional methods by providing a technology

characterized by the fact that it is possible to grow a silicon film on a large number, say 100 or more, substrates under reduced pressure, with a low price and in a simple manner.

The features of this invention involve the following 4 points: (1) a resistance heating method with a diffusion [sic; possibly "conduction"] oven is used; (2) a square inner tube is used; (3) the substrates are set vertically and parallel to the gas flow; and (4) the pressure in the reaction tube is 25,000 Pa (about 188 torr) or lower. In the following, these 4 features will be explained in more detail. Since the resistance heating method is adopted, heating can be performed without using a supporting table for heating. Consequently, the power consumption for heating can be decreased. Also, the load density of the substrates is increased, and the uniformity of the temperature in the oven can be improved. Since an inner reaction tube with nearly a square cross-sectional profile is used, it is possible to set the substrates with their surfaces parallel to the wall surface of the reaction tube. If a square fused-silica glass reaction tube is used directly instead of the square inner tube, when the pressure in the reaction tube is reduced to lower than atmospheric pressure, the reaction tube may be crushed. Consequently, a circular outer tube and a square inner tube are combined. As the substrates are set parallel to the gas flow and are kept in a vertical position, the load density of the substrates becomes higher and the gas can flow at a high speed over the substrates. Consequently, the growth rate can be high and uniform. Since the pressure in the reaction tube is maintained lower than atmospheric pressure, the gas flow in the reaction tube becomes uniform, and such uniformity can be

improved with regard to the thickness and resistance of the grown layer. The effect is particularly significant when the pressure is 25000 Pa (about 188 torr) or lower. By combining the aforementioned 4 features, the method for forming a polysilicon film or epitaxial silicon film with excellent effects is offered.

Application examples

In the following, this invention will be explained in more detail with reference to application examples.

Application Example 1: Growth of expitaxial silane

As shown in Figure 1, a fused-silica glass reaction tube with a diameter (inner diameter) of 15 cm and a length of 200 cm was loaded in a resistance heating oven with a length of 150 cm. A fused-silica glass inner tube with a 12 cm x 8 cm square cross section and a length of 180 cm was loaded in the fused-silica glass reaction tube. In a configuration shown in Figure 2, a total number of 50 silicon substrates with a diameter of 7.5 cm were set in the inner tube, with 10 substrates per stack and 5 stacks in the gas flow direction. The oven was divided into 3 portions, with the central 100-cm portion maintained at 1050 ± 2°C. As shown in Figure 1, from the left side of the oven, hydrogen gas at a rate of 30 L/min and dichlorosilane (SiH_2Cl_4) at a rate of 1.0 L/min were fed from a nozzle into the inner tube. At the same time, from the right side, the reaction tube was evacuated at a rate of 2000 L/min by a vacuum pump, so

that the inner pressure of the reaction tube was maintained at 6000 Pa (about 45 torr). After growth for 10 min, the dichlorosilane feed was stopped, and the grown wafer was cooled. The thickness of the epitaxial growth layer was then measured. It was found that except for the 5 x 2 = 10 substrates near the side walls, for the remaining 40 substrates, the uniformity was 12 μm ± 10%. The uniformity in each wafer was even better; it was ±4% or better except for the wafer-holding portion. The uniformity of the resistance was found to be slightly poorer than the uniformity of the thickness. When silane trichloride ($SiHCl_4$) and silicon tetrachloride ($SiCl_4$) are used as the feed gas, the uniformity can be further improved.

When monosilane (SiH_4) is used as the feed material, if a polysilicon tube is used as the square inner tube, although there is no falloff of the deposit from the tube walls and the surface of the grown layer has a high quality, the uniformity of the thickness is nevertheless poorer than that when a chloride feed material is used. As the pressure is decreased, the flow rate has to be increased, and the growth rate decreases which is undesirable. In order to improve the uniformity, an appropriate pressure should be selected in consideration of the power of the vacuum pump and the growth time. However, when the pressure becomes higher than 25,000 Pa (about 188 torr), the uniformity becomes much poorer.

Application Example 2: Growth of polysilicon film

A polysilicon film was grown using the same device as that used in Application Example 1. The temperature of the soaking unit inside the oven was 700°C, and every two substrates were set back to back in the reaction tube using the same method as in Application Example 1. Consequently, there were 100 substrates loaded. As shown in Figure 1, from the left side of the reaction tube, monosilane gas at a rate of 200 L/min and hydrogen gas at a rate of 30 L/min were fed into the reaction tube. As shown in Figure 1, from the right side of the reaction tube, forced evacuation was performed at a rate of 2000 L/min using a vacuum pump, and the pressure in the reaction tube was maintained at 10,000 Pa (75 torr). After growth for 10 min, the samples were unloaded from the oven for cooling. The thickness of the layers grown has a mean value of 2.5 μm. Except for the 10 substrates on the two sides, the uniformity of the thickness among the 90 wafers was better than ±7%. The uniformity in each wafer was even better (better than ±4%). When dichlorosilane was used as the feed material, the temperature in the oven was set at 900°C. The relation between the gas flow rate and the pressure inside the reaction tube is similar to that in the case of Application Example 1. When a circular tube was used in place of the square inner tube, the uniformity was not so good, with the uniformity among the wafers degraded to ±30% or poorer. This indicates how significant the effect of the shape of the tube walls is.

In the application examples explained in the above, a square inner tube was used. However, shapes near that of a square may also be adopted, such as a hexagonal cross-sectional shape prepared by taking off the four corners of a square.

Brief explanation of the figures

Figure 1 is a cross-sectional view of the oven used for crystal growth,

Figure 2 is a cross-sectional view of the fused-silica glass reaction tube.

1. Resistance heating oven
2. Fused-silica glass reaction tube
3. Fused-silica glass or silicon square inner tube
4. Substrate carrier
5. Substrate
6. Nozzle

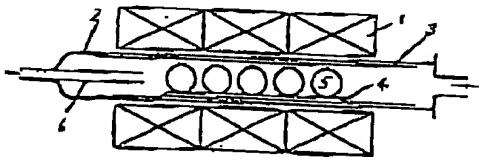

Figure 1

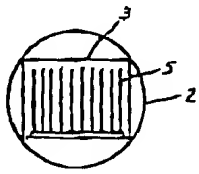

Figure 2